METHOD FOR POSITIONING MOBILE STATION AND REPEATER THEREOF

Field of the Invention

The present invention relates to the technical field of

5   mobile communication, particularly to a method for positioning

a mobile station and a repeater with auxiliary positioning

function.

Background of the Invention

10   To enable the mobile communication network to provide new

services, mobile station positioning technique needs to be

introduced to determine the position of mobile stations. In

a cellular mobile communication network, there are three basic

positioning methods: 1) Time Of Arrival (TOA) positioning

15   method, which obtains the distances from a mobile station to

the corresponding base stations through measuring TOAs from

the mobile station to three or more base stations, and then

estimates the position of the mobile station through solving

a set of circular equations; 2) Time Difference Of Arrival (TDOA)

20   positioning method, which obtains the differences in distance

from a mobile station to the corresponding base stations

through measuring TDOAs from the mobile station to three or

more base stations, and then estimates the position of the

mobile station through solving a set of hyperbolic equations;

25   3) CELL Identifier (CELL-ID) + TOA positioning method, which

firstly determines the position of the serving cell where the

mobile station is located with the CELL-IDs configured by the

network, and then further determines the position of the mobile

station in the cell with the TOA from the mobile station to

30   the serving base station.

· 2· ·

However, in traditional mobile communication systems, to ensure normal communication between mobile stations and base stations, repeaters are deployed in some areas that can't be covered by base stations; a repeater is essentially a

5   bidirectional radio frequency signal amplifier, which amplifies and forwards both uplink signals sent from a mobile station and downlink signals sent from a base station; as shown in Fig.1, in the downlink direction, the donating antenna (antenna of the serving base station) picks up signals from

10 the existing coverage area, filters out-of-band signals through a bandpass filter, amplifies the filtered signals through a power amplifier, and then resends the amplified signals to the area to be covered; in the uplink direction, signals from the mobile station in the coverage area are

15 processed in a similar way and then sent to the corresponding base station; thus, signal transmission between the base station and the mobile station is implemented. The introduction of a repeater implements normal communication between the mobile station in the base station's coverage area

20 and the base station.

The introduction of repeaters results in that the mobile stations in the coverage area of the repeater can't be positioned effectively. When a mobile station required to be positioned is in the coverage area of a repeater, for the TDOA

25 positioning method, the TDOA positioning process will fail because of the number of detectable base stations being too small; even if enough base stations can be detected, there will be very big deviations in the measured values because the signals from the base stations are forwarded by the repeater;

30 as a result, the measured TDOAs can't correctly reflect the

• 3• •

differences in distance between different base stations and
the mobile; if the measurement result is used for position
estimation, there will be a very big deviation in the determined
position of the mobile station; furthermore, the positioning
5   system is unable to determine whether the mobile station is
within coverage area of the repeater or not and whether the
measurement result is affected by the repeater or not. Likewise,
when the mobile station requested to be positioned is in
coverage of the repeater, for the TOA + CELL-ID positioning
10   method, there will be bigger errors in TOAs due to the time
delay effect resulted from the repeater and the TOA positioning
accuracy will be degraded severely; as the result, it is unable
to positioned the mobile station accurately.

15   Summary of the Invention
An object of the present invention is to provide a method
for positioning a mobile station and a repeater thereof, to
implement accurate positioning of mobile stations within the
coverage area of the repeaters and thereby improve the accuracy
20   of positioning mobile stations in the mobile communication
network.
The object of the present invention is achieved as follows:
a method for positioning a mobile station, comprising: when
receiving a positioning request from a mobile station, the
25   mobile communication network instructing repeaters to send
auxiliary positioning signals, and the mobile station
measuring the position estimation parameters according to the
received auxiliary positioning signals sent from the repeaters
and downlink signals sent from the base stations, and then
30   estimating the position of the mobile station according to the

• 4• •

measurement results, and thereby determining the position of the mobile station.

Said method for positioning the mobile station further comprises:

5   a. the mobile communication network, when receiving a positioning request from the mobile station, instructing the serving base station to measure Round Trip Time (RTT) between the serving base station and the mobile station, receiving the measurement result reported from the serving base station, and

10   at the same time sending a measurement control message to the mobile station;

b. determining all repeaters that take the serving base station as a donating base station, configuring auxiliary positioning parameters for the repeaters, and controlling the

15   transmission of auxiliary positioning signals of the repeaters to the mobile station;

c. the mobile station measuring TDOAs between the base stations and the repeaters according to the measurement control message sent from the mobile communication network and

20   the auxiliary positioning signals sent from the repeaters, and reporting the measurement results to the mobile communication network;

d. the mobile communication network estimating the position of the mobile station according to the received RTT between

25   the serving base station and the mobile station as well as TDOAs between the base stations and the repeaters, and thereby determining the position of the mobile station.

Said auxiliary positioning parameter includes: Idle Period DownLink (IPDL) parameter, the scrambling code assigned to a

30   repeater, and the carrier frequency and the transmission

· 5· ·

power(s) of the auxiliary positioning signals.

Said auxiliary positioning signal is a Primary Common Pilot Channel (P-CPICH) modulated with the scrambling code synchronized with the base station and is sent only during IPDL.

5   · Said measurement control message in step c comprises: information of the serving base station and information of the adjacent base stations; said information of the serving base station comprising the primary scrambling code of the serving base station; said information of an adjacent base station

10   comprises primary scrambling code of the adjacent base station, Relative Time Difference (RTD) between the adjacent base station and the serving base station, and width of the search window.

Said measurement control message also comprises

15   information of repeaters inserted in the information of the adjacent base stations, which comprises: scrambling codes of the repeaters, RTDs between the serving base station and the repeaters, and widths of the search windows.

Said RTDs are determined according to the distances between

20   the repeaters and the serving base station as well as the IPDL parameters, or obtained by measurement using a Location Measurement Unit (LMU).

Said scrambling code of a repeater is one of 512 primary scrambling codes and is different from those of adjacent base

25   stations individually.

Said step d comprises:

d1. the mobile communication network searching in the measurement results of TDOA according to the scrambling codes of the repeaters and determining whether the mobile station

30   is within the coverage area of repeaters according to the

• 6• •

measurement results; if so, executing step d2; otherwise executing step d3;

d2. correcting the measurement results and estimating the position of the mobile station;

5   d3. estimating the position of the mobile station directly with the measurement results.

Said step d1 comprises:

d11. the mobile communication network, according to the scrambling codes of the repeaters, determining whether the

10   measurement results of TDOA from the mobile station contain a TDOA, the scrambling code corresponding to which being that of a repeater; if so, executing step d12; otherwise executing step d3;

d12. determining the time delay and coordinate of the

15   repeater according to the obtained scrambling code of the repeater, and working out the distance between the repeater and the serving base station;

d13. determining whether the TDOA corresponding to the repeater is approximately equal to the sum of time delay of

20   the repeater and the time value obtained through dividing the distance between the repeater and the serving base station by the speed of light; if so, executing step d2; otherwise treating the repeater as a pseudo adjacent base station and executing step d3.

25   Said step d2 comprises:

d21. determining the Time of Arrival (TOA) between the serving base station and the mobile station, the time delays of the repeaters, the distances from the repeaters to the serving base station, the TDOAs between the adjacent base

30   stations and the serving base station, and the TDOAs between

· 7· ·

the repeaters and the serving base station;

d22. subtracting the TDOAs between the repeaters and the serving base station from the TDOAs between the adjacent base stations and the serving base station to obtain the TDOA
5   between the adjacent base stations and the repeater; subtracting the time value obtained through dividing the distances between the repeaters to the serving base station by the speed of light from the TOA between the serving base station and the mobile station, and subtracting the time
10   delays of the repeaters from the above-obtained results, to obtain TOAs between the mobile station and the repeaters;·

d23. determining the position of the mobile station according to the TDOAs between the adjacent base stations and the repeaters as well as the TOAs between the mobile station
15   and the repeaters, in conjunction with the coordinates of the repeaters and the coordinates of the adjacent base stations.

Said adjacent base stations include the repeater that is treated as a pseudo adjacent base station.

A repeater for implementing the function of positioning
20   the mobile station , comprising a downlink processing channel and an uplink processing channel; said downlink processing channel including an added auxiliary positioning unit, which receives downlink signals from the base station and signals carrying auxiliary positioning parameters sent from the mobile
25   communication network, generates and sends auxiliary positioning signals to the mobile station.

Said auxiliary positioning unit comprises:

a communication module, which receives signals carrying auxiliary positioning parameters sent from the mobile
30   communication network;

• 8• •

a frame timing recovery module, which receives downlink signals from the base station, processes the signals to obtain a frame synchronization signal, and sends said frame synchronization signal to a timing control module and a pilot

5   modulating module, respectively;

a timing control module, which receives the frame synchronization signal sent from the frame timing recovery module, generates and sends an pulse sequence to the pilot modulating module;

10   a pilot modulating module, which receives the frame synchronization signal sent from the frame timing recovery module and the pulse sequence sent from the timing control module, generates and sends auxiliary positioning signals to the mobile station.

15   Said downlink processing channel comprises a low noise amplifier, a filter, and a power amplifier.

Depending on the actual structure of the repeater, said auxiliary positioning unit also comprises:

a RF processing module, which comprises an automatic gain

20   control sub-module, a RF receiving and filtering sub-module, and a down frequency converter, and outputs RF signals to an intermediate frequency processing module;

an intermediate frequency processing module, which comprises an intermediate frequency filtering sub-module, an

25   analog-digit converting sub-module, and a digital down frequency converter, and receives RF signals sent from the RF processing module, processes the RF signals and generates base-band signals, and sends the base-band signals to the frame timing recovery module.

30   Said communication module receives auxiliary positioning

• 9• •

parameters from the base station through signaling.

Said communication module receives auxiliary positioning parameters via the operation and maintenance terminal of the repeater.

5   Input signals of said auxiliary positioning unit are directly obtained through coupling with the forwarding antenna.

Input signals of said auxiliary positioning unit are obtained from a node in the downlink processing channel of the

10   repeater.

Output signals of said auxiliary positioning unit are outputted after combining with signals from the repeater at a node in the downlink processing channel of the repeater.

Output signals of said auxiliary positioning unit are sent

15   via a forwarding antenna after combining with signals from the repeater before the power of the downlink processing channel of the repeater is amplified.

It can be seen from the above technical solution that the method for positioning a mobile station and the repeater

20   thereof according to the present invention comprising: firstly, determining whether the mobile station is within the coverage area of a repeater or not; if so, determining the position of the mobile station with the corresponding repeater as the reference point, thus improving the positioning accuracy of

25   the mobile station within the coverage area of the repeater; if not, positioning the mobile station with the existing mobile station positioning method; that is to say, the present invention can determine whether the mobile station is within the coverage area of a repeater according to the measurement

30   results of the mobile station, and if it is, the present

• 10• •

invention can determine the specific repeater and correlate

the measurement results with the reference point correctly.

As a result, the present invention achieves the object of

improving the accuracy of positioning the mobile station

5   within the coverage area of a repeater; in addition, the

repeater with auxiliary positioning function provided in the

present invention is simple to be implemented and doesn't

affect the structure and signaling flow of the traditional

mobile station.

10

Brief Description of the Drawings

Fig.1 is the schematic structural diagram of a traditional

repeater;

Fig.2 shows the networking structure of the mobile

15   communication network schematically;

Fig.3 is an implementing flow chart of the method according

to the present invention;

Fig.4 is a flow chart of estimating position of the mobile

station;

20   Fig.5 is a schematic structural diagram of the repeater

according to the present invention.

Detailed Description of the Embodiments

The networking structure of the mobile communication

25   network is as shown in Fig.2. To improve the accuracy of

positioning the mobile station in the mobile communication

network that is deployed with repeaters, the present invention

provides a method for positioning the mobile station, the

detailed embodiment of which is shown in Fig.3:

30   Step 1: the mobile communication network receives a

· 11· ·

positioning request message from the mobile station;

Step 2: the mobile communication network sends a Round Trip Time (RTT) measurement request to the serving base station;

Step 3: the serving base station measures RTT between itself and the mobile station, and reporting the measurement result;

Step 4: searches and determines all repeaters that take the serving base station as a donating base station according to the information from the serving base station serving the mobile station;

Step 5: the mobile communication network configures auxiliary positioning parameters for each of the repeaters determined in step 4 and initiates all of the repeaters to send auxiliary positioning signals;

Said auxiliary positioning parameters including: IPDL (Idle Period Downlink) parameters, scrambling codes corresponding to the repeaters, and carrier frequency and transmission power(s) of the auxiliary positioning signals;

Configuring the auxiliary positioning parameters for each of the repeaters determined in step 4 may be implemented through receiving auxiliary positioning parameters from the base stations through signaling, or through receiving auxiliary positioning parameters from the operation and maintenance terminal of the repeater;

Step 6: the mobile communication network sends a measurement control message to the mobile station to be positioned;

Said measurement control messages contains information of the serving cell belonging to the serving base station and information of its adjacent cells; said information of the serving cell comprises primary scrambling code of the serving

• 12• •

cell etc.; said information of the adjacent cells comprises

primary scrambling codes of the adjacent cells, RTDs between

the adjacent cells and the serving cell, and widths of the

search windows; the information of all repeaters determined

5   in step 4, which comprises scrambling codes of the repeaters,

RTDs between the repeaters and the donating base station, and

width of the search window, is also inserted in the information

of the adjacent cells and is sent together with the information

of the adjacent cells; wherein, the scrambling code of a

10 repeater is one of 512 scrambling codes and is different from

the scrambling codes of adjacent base stations; RTDs are

determined according to the distances between the repeaters

and the serving base station as well as the IPDL parameters,

or obtained by measurement using a Location Measurement Unit

15 (LMU);

    Step 7: after receiving the measurement control message,

the mobile station measures TDOAs, and reporting the

measurement results; the mobile communication network

estimating the position of the mobile station according to the

20 measurement results and thereby positioning the mobile

station.

    The mobile station position estimation process described

in step 7 comprises the following steps, as shown in Fig.4:

    Step 71: the mobile communication network obtains the RTT

25 measured by the serving base station and TDOAs measured by the

mobile station;

    Step 72: searches in TDOAs measured by the mobile station

according to the scrambling codes of the repeaters and

determines whether there is a TDOA corresponding to the

30 scrambling code of a repeater belonging to the serving cell;

• 13 • •

if not, executes step 73; otherwise executes step 74;

Step 73: determines the mobile station is not within the coverage area of any repeater, and using traditional method estimating the position of the mobile station directly

5   according to the measured TDOAs and RTT in conjunction with the coordinates of the serving base station and the adjacent base stations, and thereby determines the position of the mobile station;

Step 74: determines the mobile station has received

10   auxiliary positioning signals from a repeater and looks for the time delay T and coordinates of the repeater according to the information of the repeater;

Step 75: calculates the distance D between the repeater and the serving base station according to the coordinates of

15   the repeater and the serving base station;

Step 76: determines whether the TDOA corresponding to the repeater determined in step 72 is approximately equal to D/C+T (i.e., the sum of the time value obtained by dividing the distance between the repeater and the serving base station by

20   the speed of light and the time delay of the repeater) wherein C is the speed of light, to further determine whether the signals, from the serving base station, received by the mobile station has been forwarded by the repeater; if the TDOA is not approximately equal to D/C+T, executing step 77; otherwise

25   executes step 78;

Step 77: determines the signals, from the serving base station, received by the mobile station has not been forwarded by the repeater, then executes step 73;

Though the mobile station has received auxiliary

30   positioning signals from a repeater, the reference point for

• 14 • •

the positioning mobile station is still the serving base

station, and the repeater may be treated as a pseudo adjacent

base station; the coordinates of the adjacent base stations

used in the position estimation in step 73 include the

5   coordinates of the pseudo adjacent base station, (i.e.,

coordinates of the repeater), and the TDOAs of adjacent base

stations used in the position estimation also include the TDOA

of the pseudo adjacent base station, (i.e., TDOA corresponding

to the repeater);

10   Step 78: determines the signals, from the serving base

station, received by the mobile station has been forwarded by

the repeater, and estimating the position of mobile station

with the repeater as the reference point and thereby

positioning the mobile station;

15   The specific positioning method is as follows:

It is supposed that the corresponding TOA is obtained

according to the RTT measured by the serving base station, the

time delay of the repeater is T, the distance from the repeater

to the base station is D, the measurement value of TDOA between

20   the adjacent base station and the serving base station is $TDOAi$,

the TDOA between the repeater and the serving base station is

$TDOAo$, the speed of light is C, then, with the repeater as the

reference point, the TDOA between the adjacent base station

and the repeater is $TDOAi' = TDOAi - TDOAo$, the TOA between the

25   mobile station and the repeater is $TOA' = TOA - D/C - T$;

the position of the mobile station is calculated according

to $TDOAi'$ and TOA' in conjunction with the coordinates of the

repeater and the adjacent base station and thereby positioning

the mobile station.

30   Thus, accurate positioning of a mobile station in a mobile

· 15· ·

communication network deployed with repeaters is implemented through the above process.

On the basis of the above-mentioned method, the present invention also provides a repeater with auxiliary positioning

5   function, which is implemented through adding an auxiliary positioning unit to the downlink processing channel of a traditional repeater to implement the method for positioning mobile station mentioned above. As shown in Fig.1, a traditional repeater comprises a donating antenna and a

10 forwarding antenna; in the downlink direction, signals received from the donating base station are processed through a low-noise amplifier, a filter, and a power amplifier, and finally transmitted via the forwarding antenna; the process for uplink signal processing is the same as that for downlink

15 signal processing.

The specific structure of the repeater with auxiliary positioning function described in the present invention is as shown in Fig.5; an auxiliary positioning unit is added in the downlink direction of the repeater, said auxiliary positioning

20 unit receives downlink signals from the base station and signals carrying auxiliary positioning parameters sent from the mobile communication network, generates auxiliary positioning signals, and sends them to the mobile station; said auxiliary positioning unit mainly comprises a communication

25 module, a frame timing recovery module, a timing control module, and a pilot modulating module; wherein:

the communication module receives signals carrying auxiliary positioning parameters from the mobile communication network; said auxiliary positioning parameters

30 include IPDL parameters, the scrambling codes of repeaters,

· 16· ·

and carrier frequency and transmission power(s) of the auxiliary positioning signals;

the frame timing recovery module receives downlink signals from the base station, obtains a frame synchronization signal

5 after processing the signals, and sends said frame synchronization signal to the timing control module and the pilot modulating module respectively, to assist to generate scrambling codes and a pulse sequence;

the timing control module receives the frame

10 synchronization signal from the frame timing recovery module, generates a pulse sequence that are used to assist to control the transmission and close of the auxiliary positioning signals according to the IPDL parameters and the frame synchronization signal, and sends it to the pilot modulating

15 module;

the pilot modulating module receives the frame synchronization signal sent from the frame timing recovery module and pulse sequence sent from the timing control module; it firstly generates a scrambling code synchronized with

20 signals from base station according to the frame synchronization signal and the number of scrambling code, and then modulates P-CPICH with the scrambling code to obtain continuous auxiliary positioning signals, then modulates the continuous auxiliary positioning signals with the pulse

25 sequence, and sends it to the mobile station.

The input signals of the auxiliary positioning module may be obtained directly through coupling with the forwarding antenna, and may also be inputted from other nodes in the downlink processing channel of the repeater; the auxiliary

30 positioning signals outputted from the auxiliary positioning

· 17· ·

module may be combined with downlink signals from the repeater before the power amplification in the downlink processing channel of the repeater and then transmitted together with the downlink signals from the repeater by the forwarding antenna,

5   and may also be combined with signals from the repeater at other nodes and then transmitted.

Depending on different input signals, the auxiliary positioning unit may also comprises a RF processing module or an intermediate frequency processing module required, both of

10 which employ traditional structure; said RF processing module comprises an automatic gain control sub-module, a RF receiving and filtering sub-module, and a down frequency converter, and outputting RF signals to the intermediate frequency processing module; said intermediate frequency processing module

15 comprises an intermediate frequency filtering sub-module, an analog-digit conversion sub-module, and a digital down frequency converter, and is designed to receive RF signals sent from the RF processing module, generates base-band signals, and sends the base-band signals to the frame timing recovery

20 module.